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GIS mapping of small-scale industries in the catchment area of ‘Haaganpuro’ water stream and study of their potential chemical discharges and emissions

Helsinki Metropolia University of Applied Sciences

Bachelor’s Degree

Environmental Engineering

Thesis

18th August 2018

Author(s) Title Number of Pages Date	Rabindra Manandhar GIS mapping of small-scale industries in the catchment area of 'Haaganpuro' water stream and study of their potential discharges and emissions 23 pages + 2 appendices 18th August 2018
Degree	Bachelor's Degree
Degree Programme	Environmental Engineering
Specialisation option	Solid waste and waste water management
Instructor(s)	Kaj Lindedahl, Senior Lecturer (Supervisor)

Haaganpuro is an important fresh water stream inhabiting several species of aquatic animals as well as many other species, for example, birds and insects. It has been a spawning and thriving place for the endangered brown trout. In recent years, due to the establishment of small-scale industries in its catchment area, occasional chemical discharges and other emissions into water body has affected the quality of water, affecting the aquatic life and the water-sustained ecosystem.

This thesis project proposed here aimed at identifying and mapping these SSIs and studying their potential chemical discharges and other emissions so that effective measures could be adopted to protect the natural state of Haaganpuro.

First, basic information about Haaganpuro was collected from the supervisor. Literature review was then done to accumulate more information from other thesis papers and online sources. Eventually, multiple field visits were conducted in the catchment area of Haaganpuro to identify potentially harmful industries. Also, another student studying on same stream and the supervisor were repeatedly consulted during the field visits. Finally, the collected data were mapped using online mapping tool.

The resulting maps show the catchment areas of Haaganpuro, which are vulnerable to chemical discharges and emissions from industries. Hence, proper monitoring in those areas can be carried out frequently, and effective measures can be adopted to protect its natural state.

Keywords	water stream, Haaganpuro, catchment area, SSIs, chemical discharge and emissions, GIS, GIS mapping

ACKNOWLEDGEMENTS

I would like to extend my sincere gratitude to Metropolia Helsinki University of Applied Sciences for providing me an opportunity to conduct this thesis project.

I heartily acknowledge my respected supervisor, Senior Lecturer, Mr. Kaj Lindedahl for his tireless support, motivation, and invaluable guidance throughout my thesis study.

I would also like to thank my friends, Shree Ram Bhusal, Pradeep Mahat, Hemanta Timilsina and Bibesh Gauli for helping me to conduct the field visits on the very cold winter days. I would also like to thank my friends for sharing their ideas and experience during my thesis study.

Finally, I would like to extend my boundless gratefulness to my sister, Mrs. Meena Prajapati and my niece, Miss. Sabita Manandhar for keeping me motivated during the thesis study as well as all school days.

- Rabindra Manandhar

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List of Abbreviations

CGIS	Canadian Geographic Information System
CLI	Canadian Land Inventory
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
GIS	Geographic Information System
GNU	General Public License
Km	Kilometer
Km^2	Square Kilometer
LSIs	Large Scale Industries
M	Meter
Ppm	Parts-per-million
QGIS	Quantum Geographical Information System
SSIs	Small Scale Industries
U.S.	United States
WHO	World Health Organization

List of Symbols

%	Percentage
B	Boron
Cd	Cadmium
Cr	Chromium
Cu	Copper
Fe	Iron
Hg	Mercury
K	Potassium
M^3/s	Cubic-meter-per-second
Mb	Molybdenum
Mg	Magnesium
Mg/l	Milligram-per-liter
Mn	Manganese
Mo	Molybdenum
N	Nitrogen
P	Phosphorus
Pb	Lead
S	Sulphur
T/ha/a	Tons-per-hector-per-annum
Zn	Zinc

1 GENERAL INTRODUCTION

1.1 Introduction

Finland is situated approximately between latitudes 60º and 70º N, and longitudes 20º and 32º E (worldatlas, 2017). It has a total area of about 338,145 km^2 with mostly low and flat plains scattered with lakes and low hills. The lowest altitude of the country is 0 m at Baltic sea surface and its highest altitude is 1,328 m at Haltiatunturi (worldatlas, 2015). The land area occupies about 304,473 km^2 with more than 70 percent of it covered with thick coniferous forests and very less agricultural land. On the other hand, water bodies constitute about 33,672 km^2 i.e. about 10 percent of the total area. Most of the water bodies are commonly seen in the southern region of the country in the forms of thousands of lakes, ponds, rivers, and small water streams. (worldatlas, 2017)

This thesis focuses on a water stream in Helsinki. Helsinki is the largest southernmost city of Finland. It is also the capital city of the country. It is located approximately at 60º 10' N latitude and 24º 56' E longitude and is situated at an elevation of 26 m above sea level. Out of 5.5 million total population of Finland, Helsinki has a population of 558,457. Large population has been concentrated in this small southernmost plain and most of the water bodies are also found in this same plain (worldatlas, 2017). Helsinki has more than 25 streams in different parts of the city. They are the habitats for different species of aquatic animals and also have recreational values. (Tarvainen V. ;Koho;Kouki;& Salo, 2005)

Haaganpuro, formerly known as Mätäpuro, is one of fresh water bodies that is located in the western part of Helsinki. It is about 11.9 km long stream with side branches and has a catchment area of about 10.8 km^2 (Kokkila, ym., Haaganpuron valuma-alueen hulevesiselvitys, 2016). The stream's main channel originates from Maununneva and then flows towards south through Länsi-Pakila and Pirkkola. After that, the stream passes through Central Park and falls below the Hämeenlinna route and ends in the open sea through Pikku Huopalahti bay. About twenty-five percent of the total length of stream is pipelined in different sections (Saikku, Mätäpuro, 2008). Figure 1 shows the photo of Haaganpuro stream.

Figure 1: Haaganpuro water stream

Haaganpuro is famous for naturally growing brown sea-trout (*Salmo trutta*). However, the land use of Haaganpuro catchment area for the city's urbanization such as Hämeenlinnanväylä extension work, Helsinki-Turku railway, Hakamäentie tunnel construction, recreational activities in the parks, and potential chemical discharge and emissions from small-scale industries (SSIs) and large-scale industries (LSIs) into the stream water in 1900s affected these sea-trout thus making them an endangered species (Kokkila, ym., Haaganpuron valuma-alueen hulevesiselvitys, 2016). Recently, the quality of stream water has improved significantly due to the efforts from the City of Helsinki together with the Stream Maintenance Association. In the 2000s, the endangered sea-trout were once again naturally found in the stream. Knowing the fact that the survival of these trout depends on different activities in the catchment area of the stream, the related environmental planners have been actively working to protect the newly growing sea-trout and promote for the continuation of the restoration of the trout. For this, they added gravel and rocks to the bed of the stream, and small waterfalls were made to fascinate the fishes. Also, the association prohibited fishing in the Maunulanpuro creek to help the trout population to increase. (The City of Helsinki's Urban Environment, 2018)

1.2 Background

Haaganpuro has been polluted several times due to the occasional chemical discharge and emissions coming from the small-scale industries (SSIs) established in its catchment area. On 5th September 2010, foul smell and slurry was observed in the water at Kauppalanpuisto region of Haaganpuro stream. According to the Environment Centre of the City of Helsinki, it was due to the leakage of untreated sewage from wastewater treatment plant directly into the stream at the Kauppalanpuisto area. The leaked untreated sewage mixed into the stream water for at least four days. As a result of this, the stream was filled with grey bacterial mass thus degrading the quality of the stream water. This water could affect the spawning area of trout if the stream was not cleaned and its impacts were not minimized before nesting of trout began. Besides, occasional oil leakage from SSIs into the stream water could also be harmful for the aquatic life and the water sustained eco-system as a whole. Hence, it is necessary to adopt different preventive measures and monitor the stream water quality to protect the natural state of the Haaganpuro water stream. (Saikku, Käsittelemätöntä viemärivettä Mätäpuroon Haagan Kauppalanpuistossa, 2010)

1.3 Objectives of study

Fresh water bodies are the natural habitat for different aquatic animals as well as many other species of birds, insects, etc. As such, Haaganpuro is also a small water stream that is home to brown sea-trout and other different flora and fauna. Due to establishment of several SSIs in its catchment area, the water quality in Haaganpuro have been degraded by the potential chemical discharges and other emissions from these SSIs affecting the aquatic life and water sustained eco-system as a whole. Hence, the project laid the following objectives to manage the water quality of Haaganpuro water stream.

- To identify SSIs in the catchment area of Haaganpuro water stream.
- To study the possible chemical discharge and emissions coming out from these SSIs.
- To map the collected data of SSIs thus making easier to understand the state of Haaganpuro water stream.

1.4 Relevance of study

The rationale of GIS mapping of SSIs established in the catchment area of Haaganpuro are as follows.

- Urban development activities like establishment of SSIs near the stream disturb the aquatic and other associated eco-system. So, it is very important to develop a databank of these SSIs to protect the natural state of the stream. GIS mapping of SSIs near the water stream maintain the collected data in the databank and can help in proper planning of the development activities.
- The study of possible chemical discharges and emissions coming from the industries and maintaining it in databank on a regular basis can help to determine the exact reason for degradation of water quality. So, the guilty party can be punished in accordance with the law.
- The mapping of SSIs can also help to promote the services available in the catchment area.

1.5 Limitations

This thesis is part of a Bachelor's degree and was carried out for a short period of time without any budget allocation. Hence, there are many limitations for the thesis project.

- Due to the short duration the project, a detailed survey was not possible.
- No funding was allocated for it and all the work had to be carried out with only few available resources thus preventing detailed data collection.
- This thesis project was carried out in winter, so the weather made it very difficult to carry out field work for data collection.
- Lack of access to information of collected data caused difficulty to study their effects in the stream.
- Raw technical knowledge of GIS software hindered in the analysis of the collected data while mapping.

2 LITERATURE REVIEW

This thesis project studies the water pollution in Haaganpuro water stream. Geographical locations of sources of pollution, viz., small-scale industries (SSIs) are identified and mapped using GIS mapping tool. After that, the potential chemical discharges and emissions coming out of these SSIs that cause pollution in the stream are studied. Preventive measures are suggested for protection of the water body in the future.

2.1 Water stream

A water stream is a watercourse with a flow of less than 2 m^3/s. Those with larger flow than 2 m^3/s are rivers. Due to the less flow velocity, the water streams flowing in the urban area are often diverted for humans' uses. (Tarvainen V. ;Koho;Kouki;& Salo, 2005)

2.2 Small-scale Industries (SSIs)

Small-scale Industries are the establishments with less than 50 waged workers and yearly transaction of which is not more than 10 million euros. However, the definition of SSIs differs from country to country and one time to another in the same country and by industry. SSIs have scopes in manufacturing activities, servicing/repairing activities, retailing activities, whole-sale business, transport activities, public utilities and construction activities (Tilastokeskus, 2003). However, SSIs produce different kinds of waste chemicals or by-products and also release emissions. These waste chemicals and emissions if discharged without proper treatment can contaminate the surface water as well as ground water and affect the aquatic species.

2.2.1 Effect of pulp and paper industry on fish in Narayani River, Nepal

Narayani River, located in Central Nepal, is a home to over 100 species of fishes and endangered reptile, Gharial (*Gavialis gangeticus*). The Narayani River receives discharges from different industries like Bhrikuti Pulp and Paper Mills, which affect the habitat and health of aquatic species in it. So, a study was conducted in the river to find out the effects of industrial effluents on fish population and their health. Fish samples were collected from three different points, one of which was the mixing zone for industrial effluent. The collected data were analysed for heavy metal content by using atomic absorption spectrophotometry. The result showed that the heavy metals were found in the order of Zn > Cu > Cr > Pb > Hg > Cd. (Sah;Acharya;& Lance, 2002)

2.2.2 Effects of carpet dye industry in Bagmati River, Nepal

Bagmati River is located in Kathmandu, capital city of Nepal. There are many SSIs near this river of which most are carpet dyeing industries. It is a very common practice for these SSIs to mix their discharges directly into the river water. Although there are five treatment plants in this river, only one of them is functioning. Thus, this study was carried out to determine significant effects of effluents on the quality of water in the Bagmati River. Chromium content, DO and COD were the water quality parameters used for the study. Many samples were collected from river and dye. The dye samples showed higher chromium concentration of 1,200 – 1,400 ppm while the river samples showed lower chromium concentration of 0.03 mg/l (lower than WHO's standard chromium level in drinking water, 0.05 mg/l). So, if the effluents from dyeing industries continue to mix into river water without proper treatment, it can escalate the chromium level in the river to life-threatening state. Also, it was noticed that the dyes can increase the COD and reduce the amount of DO significantly. (Green, 2003)

Thus, industrial effluents can result into an environmental epidemic. As such, the effects of industrial pollution have to be minimised to prevent the water sources and the co-existing ecosystem. One method to prevent it is to collect the data of SSIs near the water sources and update the collected data regularly in database so that their activities can be monitored all the time using software.

2.3 GIS

The term GIS was first introduced by Dr. Roger Tomlinson in his paper "A Geographic Information System for Regional Planning". Geographic Information System (GIS) is a system that combines software and data to manage, analyse and show all forms of geographical information (Pandey & Darshana, 2014). We can view, analyse and display data using GIS, and show their relationships and patterns in the form of maps. It helps us in designing and planning on important subjects in a better way with the help of geographically referenced data that enables decision-makers to make better decisions. (Irving, 2011)

2.4 GIS mapping

GIS mapping is a geographical representation of the thematic and spatial features of physical and/or cultural environment using a mapping tool (Siad, 2011). Thematic features are represented in maps as points, lines, or area while spatial features are represented in maps as layers, coverages or layers.

2.5 GIS tool

GIS tool refers to an application that enables to process geographically referenced information and integrate the data and software to produce a map. This GIS application allows us to view maps on a computer, add new spatial information in the maps, make spatial analysis of the maps and make better planning of the geographical information.

Quantum Geographical Information System (QGIS) is one of GIS tools used to study spatial analysis. It is an open source, community-driven free GIS software licensed under the General Public License (GNU) which means that user can inspect and freely modify the source code. It can also be called a simplified version of the expensive GIS-based software that runs on devices with most operating software such as Linux, Windows, MAC-OSX and Androids. QGIS has common functions and features. (QGIS, 2016)

2.6 GIS applications

Mapping the thematic and spatial features of a subject or an object or a place to obtain its better knowledge is an important application of GIS.

- Mapping locations: GIS allows to make maps through data capture of geographical location and analysing the collected data.
- Mapping quantities: GIS also helps in mapping quantities of thematic and spatial features from the captured data.
- Mapping densities: It helps to know how the thematic and spatial features are distributed in the geographical location using uniform area unit in the map.
- Finding distances: GIS can be used to determine the distances between the features and also helps to know everything that’s occurring there.
- Mapping and monitoring change: GIS can be used to monitor every change in an area and make future predictions. (Escobar;Hunter;Bishop;& Zerger, 2000)

2.6.1 John Snow’s Cholera map

The first known case of GIS application was John Snow’s Cholera map of 1854. At the time of Cholera epidemic in London in 1854, John Snow began mapping of outbreak locations on a paper and also added located roads, property boundaries and water lines on the paper map. This helped to determine the cause of the disease; which was contaminated water from one of the major pumps. The Snow’s map had the capability of analysing the phenomena relating to their geographical positions. His findings concluded that GIS is a problem-solving tool. (GISGeography, 2017)

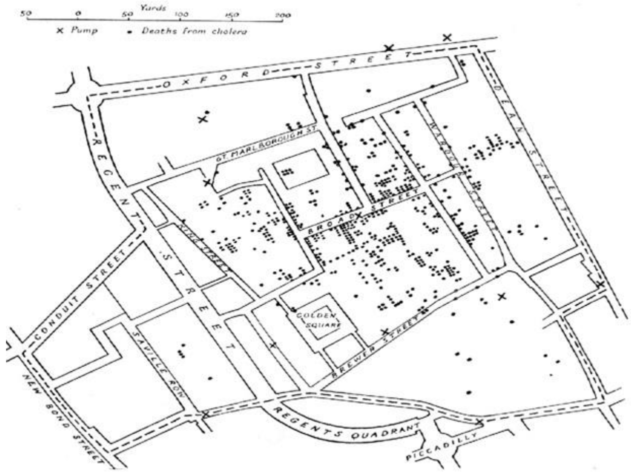


Figure 2: Cholera map (GISGeography, 2017)

Figure 2 is John Snow's famous Cholera map of 1854, trying to show connection between disease intensity with areas nearby a single water source and a pump.

2.6.2 GIS mapping in forest fire

In another case study conducted in Spain, GIS was used to make forest fire risk map for Huesca (Aragon) area.

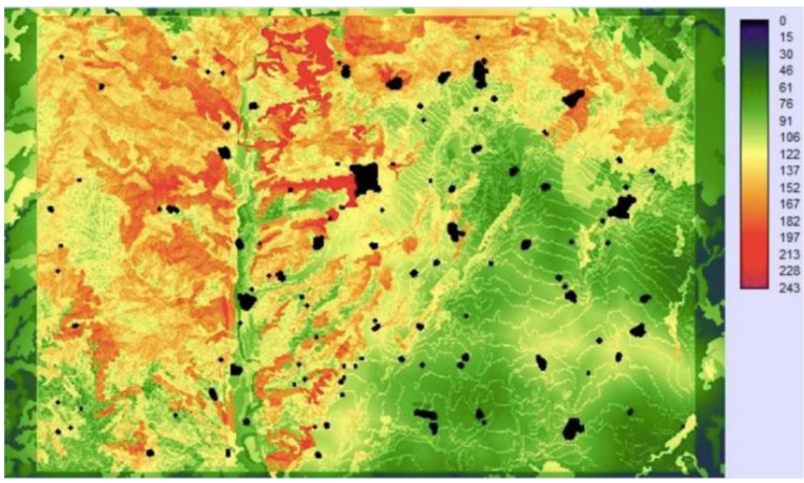
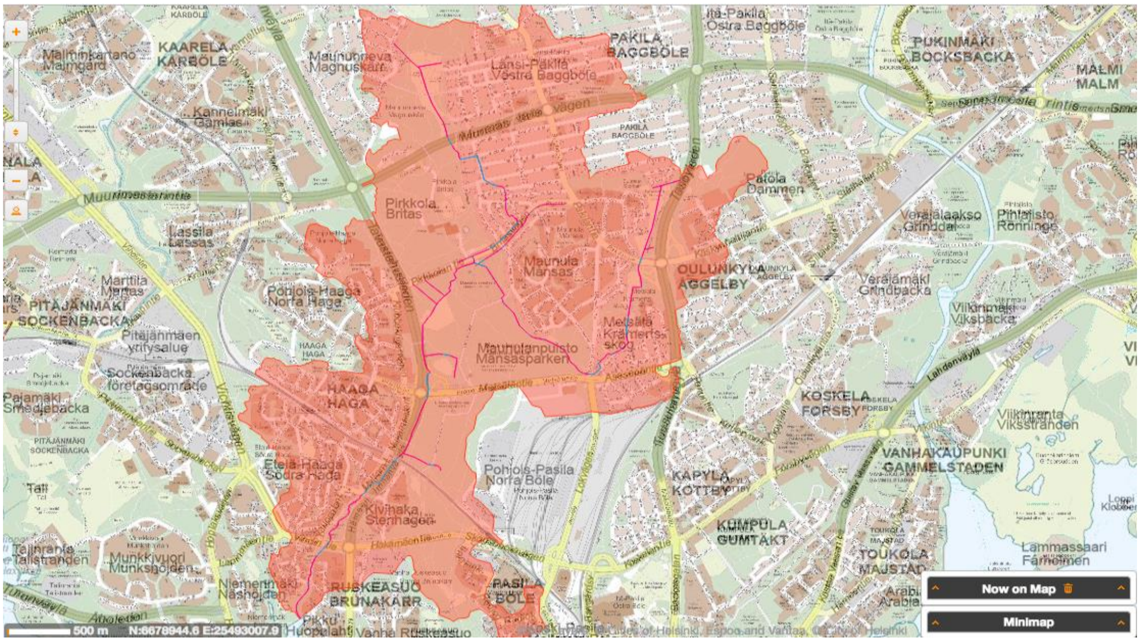


Figure 3: Forest risk GIS map (Lafragueta, 2013)

The researcher used a scale of very high, high, moderate and low risk of fire for different boundaries of the final forest fire risk map. When the number of fires that occurred in the study area in last ten years were compared, it showed that a large percentage of fires took place in the area indicated as very high or high risk. Hence, local authorities and forest fire management committee could use this GIS map to minimize fires in future. (Lafragueta, 2013)

3 STUDY AREA

3.1 Map of Study area



Map 1: Haaganpuro and catchment area (City of Helsinki, 2017)

3.2 Site Description

Haaganpuro has a total length of about 11.9 km and catchment area of about 10.8 km^2 (Kokkila, ym., Haaganpuron valuma-alueen hulevesiselvitys, 2016). About one-third of this area is impermeable to water. All the rainwater that falls in the stream flows into the Pikku Huopalahti bay and ends into the Baltic Sea. The stream passes along several residential, commercial and forest areas. The eastern branch of the stream, also called Maunulanpuro creek, flows along the Maunula nature trail. The nature in and along the stream is rich and diverse. The stream is the home to several aquatic animals, insects, and most importantly endangered brown trouts.

The catchment area of Haaganpuro consists of several floral areas, a bird area and a flying squirrel area. Also, several green-shield mosses inhabit in the catchment area. There is a protected habitat in Maunulanpuisto and two important geological sites in the stream's catchment area. Also, a pond, named Maunulan lampi is situated in Maunula and two springs are located in Maunula and Kivihaka. Two cemeteries and few vegetation areas are also located in the catchment area. Besides, the catchment area consists of several built structures such as schools, universities, hospitals, residential and office buildings, restaurants, hotels, highways, gas stations and car repair and wash shops.

4 MATERIALS AND METHODS

4.1 Collection of information/ Data

4.1.1 Selection of site

The thesis project focused on the data collection of all SSIs established in the catchment area of the Haaganpuro water stream. Thus, places within the boundary of the catchment area on either side of the water stream were selected to conduct the study. The starting point of the study was Maunenneva which ended at Pikku Huopalahti bay through Länsi-Pakila, Pirkkola, Maunula, Suursuo, Oulunkylä, Metsälä, Haaga, Etelä-Haaga, Pohjois-Pasila, Kivihaka and Ruskeasuo.

4.1.2 Discussion with Supervisor

The thesis study was assigned by the supervisor as a small part of an ongoing larger project. Thus, after confirming the study area, the supervisor provided some relevant information of the topic. Also, meetings with the supervisor were organized several times for more information during the course of the project.

4.1.3 Desk study

Relevant case studies and thesis papers were studied to get detailed knowledge of the topic. Then, additional necessary information about the catchment area of Haaganpuro water stream was collected from online sources such as Helsinki Map Service, Google Earth Map, and others.

4.1.4 Direct observation

After the initial desk study of the Haaganpuro water stream, field visit method was used to collect the genuine data of SSIs located within the selected parameters of the water stream. Direct observations of the study area were conducted out on 6th March 2018, 28th March 2018, 1st April 2018, 5th April 2018 and 9th August 2018 to find out every SSI located in the selected zone. Android devices were used during the field visit to locate the geographical locations of the SSIs that were found.

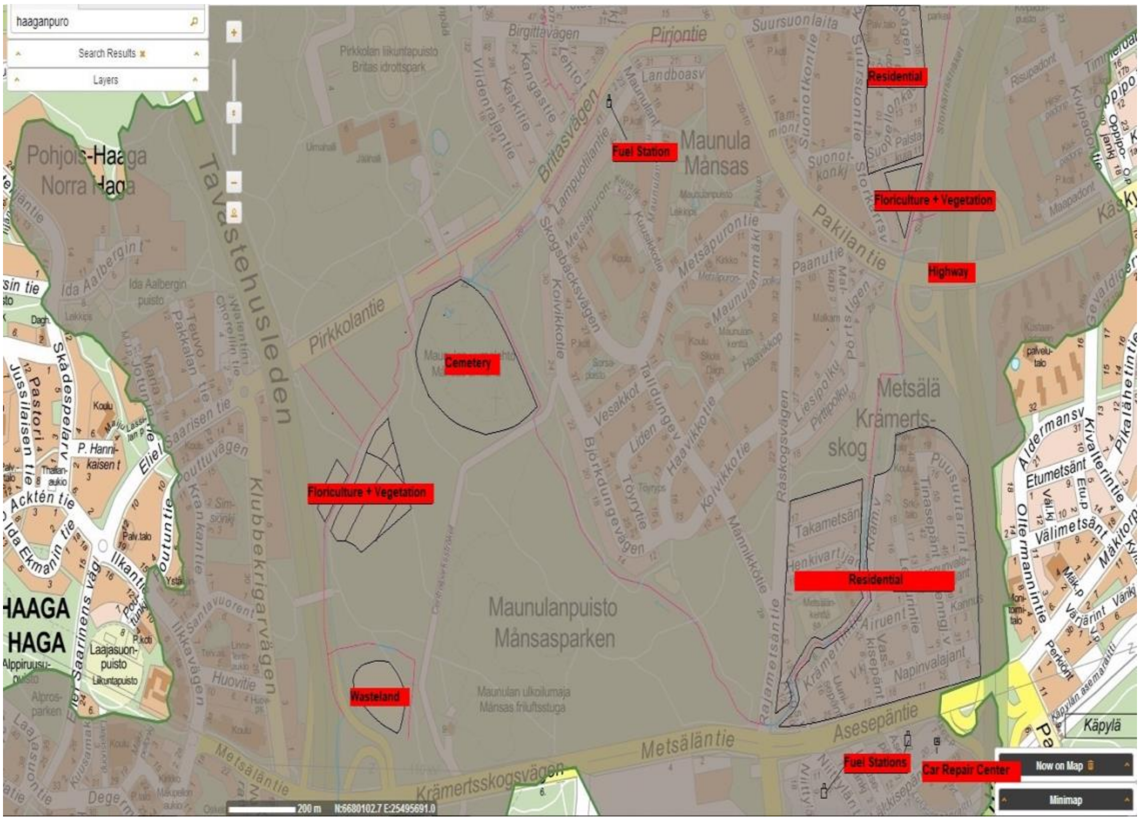
4.1.5 Collaboration with another group

Another group was conducting a similar project, and there were consulted to collect their ideas regarding the topic. Also, this group assisted in field data collection.

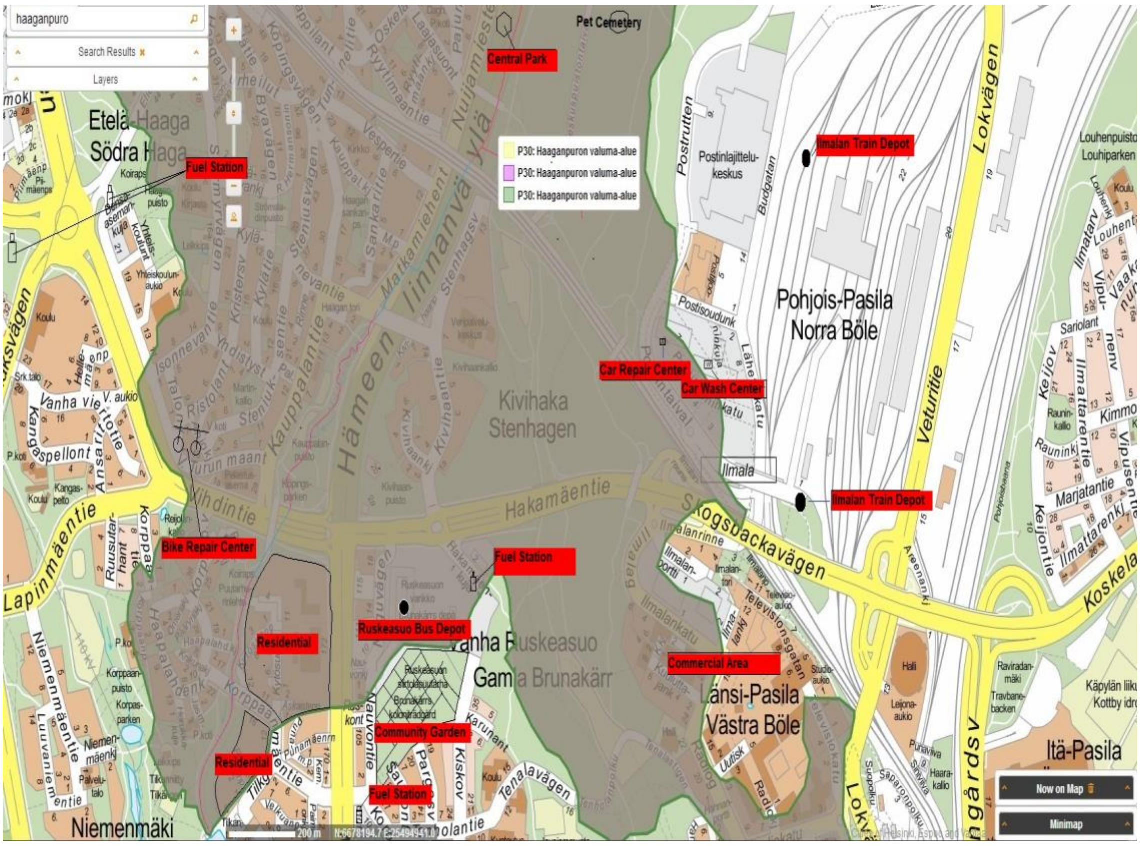
4.2 GIS mapping of collected data

Different SSIs that were identified during the field visit are agricultural production, fuel stations, bike / car service centres, bus / train depots, highways and other construction projects, etc. These SSIs are located within the catchment area on either side of Haaganpuro or on the vicinity of its catchment area. The water stream is very long. Thus, its catchment area was divided into three parts, viz., starting point (Maununneva), middle part (Maunula) and the end point (Pikku Huopalahti bay). Division of the catchment area was created to make the mapping easier and look better. Mapping of the collected data was done by using online GIS mapping software. Only the basic features of the mapping tool were used for this thesis work due to the lack of its advanced technical knowledge.

Map 2: Starting point of Haaganpuro (Maununneva)



Map 3: Middle part of Haaganpuro (Maunula)



Map 4: End point of Haaganpuro (Pikku Huopalahti bay)

4.3 Problems of collection of information and GIS mapping

Several problems arose during the field visit and while mapping the collected data:

- The study area was wider, which consumed much time for the field visit.
- Forest areas covered a large part of study area. This made the study challenging in these forest zones.
- Stream was piped and undergrounded at many places. This also made study complicated as we could not identify the further stream outlets several times.
- Information at several places of the study area were in Finnish, thereby, making it impossible to understand for the English-speakers on-field.

5 RESULTS AND DISCUSSION

Haaganpuro, a natural habitat for endangered brown sea-trout, has been polluted several times due to occasional chemical discharge and emissions coming from SSIs established in its catchment area threatening the survival of the sea-trout, other aquatic life and the water sustained eco-system. Hence, a research project was carried out to identify these SSIs and study their possible chemical discharge and emissions to manage the water quality of Haaganpuro. After several field visits in the stream's catchment area, the research group came up with following findings which can potentially cause water pollution in the stream.

5.1 Agricultural production (Floriculture and Vegetation)

The team on-field identified three floriculture and vegetation zones along the stream. Two of those were located at the starting points of the stream, Maununneva and Suursuo. The last one was sited in Maunula nearby urn cemetery. Different kinds of fertilizers are used to maximize the agricultural production. The amount of nutrients differs according to the types of fertilizers.

Figure 4: Rose fertilizer *(Kekkilä Oy, 2017c)*

Rose fertilizer (Figure 4) contains nitrogen, phosphorus and potassium in the proportion of 22:4:19. It also contains Boron (B), Copper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mb) and Zinc (Zn). It mixes with water and provides the roses with strong shoots, buds and rich, lifelong flowering. (Kekkilä Oy, 2017c)

Figure 5: Herbaceous and Rodent fertilizer (Kekkilä Oy, 2017b)

Herbaceous and rodent fertilizer (Figure 5) has NPK composition of 9-5-18. Its other nutrients are Mg, S, Cu, Fe, Mn, Mb, and Zn. This fertilizer improves the colour of perennial plants and flower buds and maintains acidity in soil. (Kekkilä Oy, 2017b)

Figure 6: Garden fertilizer (Kekkilä Oy, 2017a)

Garden fertilizer (Figure 6) has NPK in the proportion of 4.5:1:7. Besides, it contains other nutrients such as S, Mg, B, Cu, Fe and Zn. This fertilizer invigorates evergreen plants for good growth and gives strength and endurance to all plants in the garden. (Kekkilä Oy, 2017a)

Likewise, different types of pesticides such as herbicides, insecticides and fungicides. are also used in plants to control weeds, pests and kill other harmful organisms. Ingredients used in herbicides are Terbuthylazine, Glyphosate and Quinoclamine, Glufosinate-annonium. Similarly, ingredients in fungicides are Chlorothalonil, Maneb, Tiram, Propiconazole, Benomyl and Triadimefon. Also, ingredients used in insecticides are Permethrin, Dimethoate, Oxydemoton-methyl and Cypermethrin (Juntunen, 2001).

Figure 7 shows use of pesticides in Finland from 1955 till 2013.

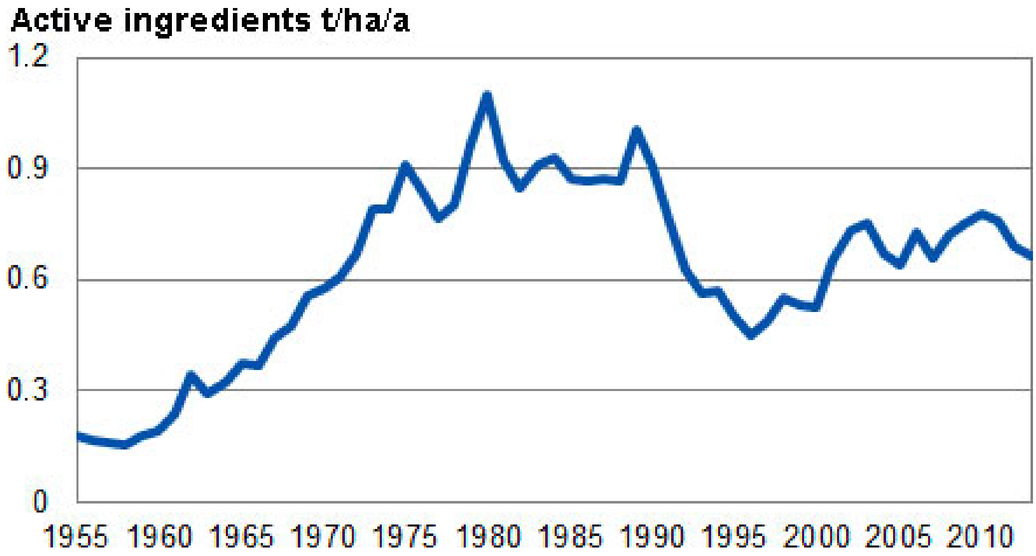


Figure 7: Use of pesticides in agriculture in Finland in 1955-2013 (Finnish Environment Institute, 2016)

The chart shows that the use of pesticides decreased in 1990s but has increased since 2000s. The use of herbicides is the highest in Finland, accounting about 77 percentage of total active ingredients sold in Finland in 2013. Also, a greater proportion of fungicides sold include substances that are more hazardous (Finnish Environment Institute, 2016).

Hence, the use of fertilizers and pesticides can cause degradation of the water quality if their ingredients somehow mix into the water source thereby negatively affecting the water creatures and their natural habitat. Hence, the environmental impact of use of fertilizers and pesticides in agricultural production has increased.

5.2 Fuel Stations

Helsinki, the business centre of Finland, has many highways and many other road networks for the huge traffic. Thus, many fuel stations are established near these highways and small networks. During field visit, the team found more than seven fuel stations in the catchment area of Haaganpuro. Most of these were established close to the stream route.

Key elements found in petroleum fuels are carbon and hydrogen. It also contains significant amounts of nitrogen, sulphur and oxygen and smaller amounts of nickel and vanadium. The occasional oil leakages from these fuel stations cause mixing of these elements into water and can pollute the water and adversely affect the aquatic life.

The gasoline also contains certain percentage of ethanol as shown below.

Figure 8: Ethanol Content in motor gasoline

Figure 8 shows the gasoline with 5% ethanol content is termed as E5 and the gasoline with 10% ethanol content is called E10 (U.S. Energy Information Administration, 2018). According to Cassidy (2016), a higher percentage of ethanol in gasoline releases more toxic pollutants into water source causing more toxic algae blooms, thus ultimately affecting the water lives. (Cassidy, 2016)

5.3 Bike / Car Service Centres

There were few bike and car repair / wash centres in the catchment area of Haaganpuro. The on-field team also noticed an automated wash centre in Ruskeasuo. These service centres are required to use only authorized chemicals and detergents and duly test the vehicle washing operations. The car wash facilities are also instructed to follow the manual released by Finnish Petroleum and Biofuels Associations that contain information about management of waste waters. The waste waters from car wash facilities cover a large proportion of the services centres' waste waters. Other wastes are sewage waters and oily surface waters produced by the use of strong detergents in the service site. The use of strong detergents may hinder the functioning of waste water treatment processes causing run-off and ultimately result in mixing into the stream water through rainwater. Also, the waste waters in controlled car wash systems are sent for further treatment process, but the waste waters produced at the self-serve car wash centres are generally released in the soil or general sewage network. Hence, these waste waters can finally mix with the stream water posing threat to water animals. (Petroleum & Biofuels Association - Finland, 2015)

Figure 9: Chemicals for car repair and wash services

Figure 9 illustrates the chemicals for car repair and washing service. These chemicals after use should be taken to an authorised collection point because if they are discharged into water via drains, they can cause severe health hazards to the aquatic lives.

5.4 Cemetery

The on-field study team located two cemeteries in the catchment area. The Urn cemetery, biggest urn cemetery in Finland is situated in Maunula and the other is pet cemetery situated in Kivihaka. Haaganpuro water runs along the urn cemetery. These cemeteries have lesser effects unlike previous ones; however, the rainfall water can carry hazardous materials from the cemeteries and mix into the stream. Also, the on-field study team found out the pipelines coming from cemetery area that end in the stream.

5.5 Highways and other Construction projects

Different urbanization projects such as Hämeenlinnanväylä extension work, Helsinki-Turku railway and Hakamäentien tunnel construction etc. are in progress in the stream's catchment area. The harmful emissions from these projects can have undesirable impacts on the water system. Also, recreational activities in the parks that are situated in the vicinity of the stream can cause to affect the health of living beings in the water body. The harmful emissions can be loud noises, foul gases or other wastes.

5.6 Train and Bus depots

There are train and bus depots in the catchment area of the stream. Train depots have been built in Ilmala and bus depot has been built in Ruskeasuo. In these depots, trains and buses are serviced and cleaned every day in their respective depots. The wastes released from the servicing and cleaning of trains and buses can be flown with rainfall water and mixed into the stream water thus causing harmful effects in the water ecosystem.

6 CONCLUSIONS

The thesis study was aimed at identifying the SSIs in the catchment areas of Haaganpuro water stream. Direct Observation method was adopted for the study. After several field observations, several SSIs and other elements that could affect the water system were located and mapped using online mapping software. The resulting maps show that most SSIs are closely established to the water body. The floriculture and vegetation growing zones share the same border with the water body. Thus, the possibility of mixing of chemicals used in these agricultural productions into the stream is very high. Also, many gas stations were spotted throughout the catchment area. In case of occasional fuel leakage from these stations, it would not take long time for the chemicals to enter water body with run-off water or rainfall water. The waste waters from the self-serve car wash systems are released in the soil or general sewage network. These waste waters ultimately mix into the nearby water source through underground perforation. As these waste waters contain very harmful chemicals, they can be deadly to the aquatic lives. The loud noise emissions coming from constructional works and recreational activities in the parks nearby the water source can disturb the aquatic lives and their spawning can be affected. Hence, it is necessary to monitor these SSIs regularly to prevent from any accidental chemical discharges and emissions. Also, the laws and regulations made for the protection of water body and aquatic life should be enforced strictly. High penalty should be fined to the guilty and compel them to contribute in restoration of the environment.

However, despite of existence of several potential factors that can affect Haaganpuro and its water sustained eco-system, the state of the stream water is improving. The city of Helsinki and Stream Maintenance Association have been working together to upgrade the state of the stream. They have been actively involved in protecting the endangered brown sea-trout and promote the continuation of their restoration by prohibiting fishing in the Maunulanpuro creek.

This thesis is also a small part of the larger project for protection of Haaganpuro stream and its aquatic life. Hence, every environment loving person has to contribute for the protection of this beautiful environment around him/her.

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APPENDIX 1: Photographs of the Field Study

Picture 1.1: Starting point of Haaganpuro (Suursuo) dated 1st April 2018

Picture 1.2: End point of Haaganpuro (Pikku Huopalahti) dated 9th August 2018

Picture 1.3: Pipeline Inlet of Haaganpuro dated 28th March 2018

Picture 1.4: Pipeline Outlet of Haaganpuro dated 28th March 2018

Picture 1.5: Floriculture + Vegetation in catchment area dated 9th August 2018

Picture 1.6: Floriculture in catchment area dated 9th August 2018

Picture 1.7: Vegetation in catchment area dated 9th August 2018

Picture 1.8: Timber tree in catchment area dated 1st April 2018

Picture 1.9: Residential wastewater pipeline outlet into Haaganpuro dated 6th March 2018

Picture 1.10: Residential wastewater pipeline outlet into Haaganpuro dated 1st April 2018

Picture 1.11: Residential + Commercial area in catchment area dated 6th March 2018

Picture 1.12: Residential Area in catchment area dated 1st April 2018

Picture 1.13: SSIs in catchment area dated 5th April 2018

Picture 1.14: SSI in catchment area dated 5th April 2018

Picture 1.15: Wastewater pipeline outlet into Haaganpuro dated 1st April 2018

Picture 1.16: Wastewater pipeline outlet into Haaganpuro dated 1st April 2018

Picture 1.17: Haaganpuro along Maunula Natural Trail dated 9th August 2018

Picture 1.18: Haaganpuro along Maunulan Floriculture + Vegetation Garden dated 1st April 2018

APPENDIX 2: Composition of Different Fertilizers

Table 2.1: Composition of Rose Fertilizer

S.N.	Composition	Percentage (%)
1	N	22.3
2	P	4
3	K	18.6
4	B	0.03
5	Cu	0.014
6	Fe	0.18
7	Mn	0.10
8	Mo	0.001
9	Zn	0.023

Table 2.2: Composition of Herbaceous and Rodent Fertilizer

S.N.	Composition	Percentage (%)
1	N	9.4
2	P	5.4
3	K	17.9
4	Mg	1.7
5	S	7.8
6	B	0.03
7	Cu	0.012
8	Fe	0.20
9	Mn	0.12
10	Mo	0.001
11	Zn	0.025

Table 2.3: Composition of Garden Fertilizer

S.N.	Composition	Percentage / Amount
1	N	4.5 %
2	P	1.1 %
3	K	6.6 %
4	S	1.4 %
5	Mg	0.5 %
6	B	15 mg/kg
7	Cu	35 mg/kg
8	Fe	005 % (or 400 mg/kg)
9	Zn	0.005 % (or 130 mg/kg)
10	Moisture	10 %
11	Organic matter	65 %
12	Dry matter	90 %